RIVISTA DI
DIRITTO ED ECONOMIA DELLO SPORT

ISSN 1825-6678
Vol. VI, Fasc. 1, 2010

POINT SPREAD SHADING AND BEHAVIORAL BIASES IN NBA BETTING MARKETS

by *Brad R. Humphreys*[*]

SUMMARY: Introduction – 1. A Simple Model of Sports Book Operation – 2. Data Description – 3. Evidence of Shading in NBA Point Spread Betting – 4. Discussion and conclusions – References

KEYWORDS: *Sports betting, balanced book model, NBA, point spread*

JEL CLASSIFICATION: L83, G24, D49

Introduction

Economists' understanding of the operation of sports betting markets has changed significantly over the past few years. Previous research emphasized the efficient nature of sports betting markets, assumed to be composed of informed bettors searching for unexploited profit opportunities and book makers setting prices that fully reflected all available information about teams and expected game outcomes.[1] In this view, sports book makers play a passive role in the betting market, setting odds or point spreads to equalize the volume of betting on each side of a game or match and earning a certain profit from a commission charged to bettors. Recently, Levitt challenged this description of sports betting markets, pointing out that, based on evidence from a betting contest involving National Football League (from now on NFL) games, the point spreads set by book makers did not balance the betting on each side of games, leading book makers to actively participate in the market by «taking a position» on games by accepting an unbalanced volume of bets on games and exposing themselves to additional risk.[2] Levitt developed a model that demonstrated how the presence of uninformed bettors in the market lead book

[*] Associate Professor of Economics and Chair in the Economics of Gaming. Department of Economics, University of Alberta. E-mail: brad.humphreys@ualberta.ca.

[1] R. SAUER, *The Economics of Wagering Markets*, in *J. of Ec. Lit.*, vol. 36, 1998, 2021-64.

[2] S. LEVITT, *Why Are Gambling Markets Organised so Differently from Financial Markets*, in *The Ec. J.*, vol. 114, 2004, 223-246.

makers to systematically change prices to increase profits by exploiting betting by these uninformed bettors, motivating the observed outcomes in the contest he analyzed.

Two competing models currently exist that describe sports betting markets. The standard model features informed bettors and profit maximizing book makers who maximize profits with little risk by setting prices to balance the volume of betting on either side of games. Under this model, book makers can accurately predict how bettors will behave, and set their prices to equalize the volume of betting on either side of games; the prediction of a balanced volume of betting is a key feature of this model. The alternative model features both informed and uninformed bettors participating in the market and profit maximizing book makers who allow unbalanced bet volume to occur in order to increase profits above the level that would be earned if the volume of betting was equal on each side of games. Under this model, book makers systematically exploit uninformed bettors to increase their profits; an unbalanced volume of betting is a key feature of this model.

In this paper, I develop evidence of unbalanced betting volume in the point spread betting market for National Basketball Association (from now on NBA) games in the 2003/2004 through 2007/2008 seasons, and explore the possibility that this unbalanced betting volume reflects book makers systematically exploiting uninformed bettors participating in this market. The evidence clearly shows that betting on the average NBA game over this period was unbalanced, with a majority of the bets placed on the stronger team. In addition, an analysis of the relationship between the number of bets placed on the stronger team and the probability that a bet on the stronger team pays off suggests that book makers may systematically alter point spreads to exploit these imbalances in bet volumes.

This paper focuses on point spread betting on NBA games. Point spread betting is commonly used for betting in North America on professional and college (American) football and basketball, but not used much elsewhere. The alternative betting system, odds betting, is used frequently in betting on horse racing, football matches, ice hockey, baseball, and other sports around the world. In odds betting, a bettor bets on the outcome, in terms of winning or losing a game, race or match, and bets on the stronger team or horse pay off at lower odds.

Point spread bets are not based on wins or losses by teams; point spread bets are based on the difference in the number of points scored by the two teams participating in a game. For example, suppose that the Boston Celtics are playing the Chicago Bulls in Chicago, and Chicago is considered the stronger team by sports book makers and bettors. In order to take bets on this game, a book maker posts a point spread, or line, that specifies the number of points by which Chicago must win the game for a bet on Chicago to pay off. If Chicago was considered much stronger than Boston, this point spread might be seven points. In the Las Vegas sports betting jargon, the line would be Boston at Chicago -7; Boston would be called a «seven point underdog». In this case, the Chicago Bulls would have to win the game by 8 or more points for a bet on the Bulls to pay off. If the Bulls win by six points or less, or the Bulls lose the game, then bets on the Bulls lose and bets on the Celtics win. Note that even in games with teams of unequal ability, point spread betting can result in interesting wagers. In games played by teams of vastly unequal strength, the point spread is simply made very large by the book maker. For example, if the Chicago Bulls were the best team in the league and the Boston Celtics the worst, a book maker could set the line on the game at 20 points, meaning that Chicago would have to score 21 points more than the Celtics for a bet on the favored Bulls to pay off.

Point spread betting works on a «risk 11 to win 10» basis. A bettor wagering on the Chicago Bulls in the above example would place a $110 dollar bet on the Bulls. If the Bulls win the game by 8 or more points, the bettor gets his $110 back and wins an additional $100. If the Bulls win by 6 or fewer points, or lose the game, the bettor loses $110. If the Bulls win by exactly 7 points, the bet is a «push» and all money is refunded to bettors. The additional dollar risked is a commission collected by the book maker, and is often called «vigorish» or simply «the vig» by sports bettors.

Point spreads are set by sports book makers in Las Vegas, and point spread betting takes place at these sports books, or at online, off-shore internet betting sites. The point spreads offered by different bookmakers on games are almost always identical, offering little chance for arbitrage opportunities by placing bets with multiple book makers. The point spread on a game can change over time, but the bettor's wager is based on the point spread that was in place at the time the wager was made.

1. A Simple Model of Sports Book Operation

Levitt developed a formal model of point spread betting.[3] In this model, the book maker takes bets on a game between two teams, Team 1 and Team 2, and chooses the probability that a bet on team 1 wins, π_1, by setting the point spread to maximize expected returns on the game. Since only two teams are involved, the probability that a bet on Team 2 wins is $\pi_2 = (1-\pi_1)$. The model did not explicitly include the point spread on the game as a variable. Instead, bettors implicitly interpret the point spread in terms of the probability that a bet on Team 1 will win, and decide whether to bet on Team 1 or Team 2. If f_1 represents the fraction of bets placed on Team 1 and f_2 represents the fraction of bets placed on Team 2, then the expected return to the book maker from point spread bets on this game is

$$E[R]= [(1 - \pi_1)f_1 + (1 - \pi_2)f_2](1 + v) - (\pi_1 f_1 + \pi_2 f_2) \tag{1}$$

[3] S. Levitt, *Why Are Gambling Markets Organised so Differently from Financial Markets*, cit., 2.

The first term on the right hand side of equation (1) is expected winnings by the book maker from losing bets and *v* is the commission charged on point spread bets. The second term on the right had side of equation (1) is expected losses by the sports book on winning bets. Humphreys extended this model by assuming a functional relationship between the probability that a bet placed on Team 1 wins, π_1 and the fraction of bets placed on Team 1, f_1.[4] Formally

$$\pi_1 = \beta f_1 \tag{2}$$

This equation can be interpreted in terms of the difference between the objective probability that a bet on Team 1 wins, π_1, and bettors' subjective probability that a bet on Team 1 wins, reflected by the fraction of bets placed on Team 1, f_1. π_1 depends on the point spread, the relative strengths of the two teams, and random factors that take place during the game. f_1 depends on the point spread, bettors perceptions of the relative strengths of the two teams, bettors perceptions of the random factors that take place during the game, and also on bettors preferences for betting on the two teams involved in the game. The parameter β reflects the presence of potential biases in bettors' perceptions of the probability that a bet on Team 1 will win, and the presence of uninformed bettors in NBA point spread betting markets. If $\beta = 1$, then bettors are unbiased in the sense that their subjective assessment of the probability that a bet on Team 1 will win is equal to the objective probability π_1. But if β is not equal to 1, then bettors will be biased in that their subjective assessment differs from the objective probability π_1. β might be different than one because bettors derive utility from the act of betting, as in the utility of gambling model developed by Conlisk.[5] Alternatively, bias in bettors' subjective probability that a bet on Team 1 would win could arise from bettors making persistent mistakes like those described by Tversky and Kahneman.[6] The presence of uninformed bettors in horse race betting has been hypothesized as a cause for the well-established favorite-longshot bias in those markets.[7]

Substituting equation (2) into equation (1) and solving for the fraction of bets placed on Team 1 that maximizes the expected returns yields an expression for the value of bets placed on Team 1

$$f_1 = \frac{(1+\beta)}{4\beta} \tag{3}$$

[4] B. R. Humphreys, *Prices, Point Spreads and Profits: Evidence from the National Football League*, University of Alberta Department of Economics Working Paper n. 2010-05, 2010.

[5] J. Conlisk, *The Utility of Gambling*, in *J. of Risk and Uncert.*, vol. 6, 1993, 225-75.

[6] A. Tversky, D. Kahneman, *Judgment under Uncertainty: Heuristics and Biases*, in *Science*, vol. 185, 1974, 1124-1131.

[7] See L. Coleman, *New Light on the Longshot Bias*, in *Ap. Ec.*, vol. 36, 2004, 315-326 for a recent review.

Equation (3) shows that attracting an equal volume of bets on each side of a game is only profit maximizing for a book maker if the market contains only unbiased bettors, in the sense that β =1 reflects lack of bettors' bias. If bettors' subjective probability that a bet placed on Team 1 will win differs from the objective probability that a bet on Team 1 will win, then the book maker can increase the expected return by accepting an unequal volume of bets on the game. Thus the balanced book model described above emerges as a special case of this model.

A book maker increases expected returns when uninformed bettors are betting on a game by reducing π_1, the probability that a bet on Team 1 wins, if the uninformed bettors prefer to bet on Team 1. Suppose that some exogenous fraction of uninformed bettors will always bet on Team 1 at any point spread, either because they derive utility from betting on Team 1 or they make persistent, Tversky-Kahenman type mistakes based on heuristics that lead them to bet on Team 1, while informed bettors use all available information to form an expectation of π_1, $E[\pi_1]$ and bet on Team 1 only if $E[\pi_1]$ exceeds some threshold value. If the book maker sets the point spread to balance the volume of bets by informed bettors on each team, the overall volume of bets will still be unbalanced because the uninformed bettors only bet on Team 1. In this case, bet volume on games would be imbalanced, but the probability that a bet on Team 1 wins would be π_1=0.5, since that value balances informed betting equally on the two teams. The book maker would earn a certain profit from the commission charged to losing bettors, but in about half of the games, the book maker suffers a relatively large loss because the favored team, which attracts a majority of the bets, covers the point spread; in the other half of the games, the book maker gets a relatively large win because the favored team does not cover the point spread.

Alternatively, if there are enough uninformed bettors in the market, the book maker could systematically change the point spread to reduce π_1 below 0.5. This leads to an imbalance in betting by informed bettors, who know that the point spread set is not consistent with π_1=0.5. The book makers' expected returns could still increase in this case, because uninformed bettors still bet on Team 1, even at this unfavorable point spread. The volume of bets on either side of this game depends on the number of informed and uninformed bettors that bet on the game.

This simple model of sports book operation provides three predictions about outcomes in point spread betting markets. First, a balanced book does not necessarily maximize expected returns for book makers. Second, the presence of unbalanced betting on games indicates the presence of uninformed bettors in point spread betting markets. Third, the presence of unbalanced betting combined with evidence that the probability that a bet on the favored team wins less than 50% of the time suggests that book makers shade point spreads in a way to exploit uninformed bettors. In the next section, I look for evidence of these outcomes in point spread betting on NBA games.

2. Data Description

The data analyzed were obtained from Sports Insights, an online sports gambling information service. Sport Insights recently began making betting data, including information on betting volume on individual games, available for a fee. Sports Insights has agreements to obtain and publish betting volume data from four large on-line sports book makers: BetUS, Carib Sports, Sportbet, and Sportsbook.com. The data files that Sports Insights makes available include the opening and closing point spreads, the final score of the game, and the percentage of bets reported on each side of point spread bets for all regular season games played in the NBA in the 2003/2004 through 2007/2008 seasons. The betting volume data distributed represents the average betting volume across the four participating sports books. Note that the betting volume data represents the fraction of bets placed on each side in the point spread betting market, and not the fraction of dollars bet on each side. Data on the fraction of dollars bet are not available from Sports Insights. In the empirical analysis, I assume that the average size of a bet placed on each team is equal, so that the number of bets placed on each team is equal to the dollars bet on each team. A cursory examination of data on dollars bet on each side of games at various gambling web sites indicates that this assumption is reasonable; unfortunately, I lack comprehensive data on total dollars bet on each game over this sample period.

I analyze betting on regular season NBA games. The NBA regular season consists of 82 games, 41 at home and 41 away from home and runs from late October or early November until mid April. The NBA also plays a pre-season schedule of games lasting about a month prior to the start of the regular season, and some wagering takes place on these games. I ignore betting on pre-season games. The NBA also holds an annual post-season tournament to determine the league champion. I also ignore betting on post-season NBA games.

A number of papers have analyzed betting on NBA games. Sauer summarized the early literature on NBA betting.[8] Much of this early literature focused on assessing the efficiency in NBA point spread betting markets by using regression models to determine of the point spread was an unbiased, efficient predictor of game scores. Recent research looks for evidence of unexploited inefficiencies and bettor misperceptions in NBA point spread betting markets. Paul and Weinbach found evidence of inefficiencies in NBA bets on large home underdogs, and teams on long win streaks over the 1996/1997 to 2001/2002 seasons.[9] Gandar, Zuber and Dare examined a related market, betting on the total score in NBA games, for the 1986/1987 through 1996/1997 seasons.[10] They found evidence that

[8] R. Sauer, *The Economics of Wagering Markets*, cit., 1.

[9] R. J. Paul, A. P. Weinbach, *Bettor Misperceptions in the NBA: The Overbetting of Large Favorites and the «Hot Hand»*, in *J. of Sp. Econ.*, vol. 6, n. 4, 2005, 390-400.

[10] J.M. Gandar, R.A. Zuber, W.H. Dare, *The Search for Informed Traders in the Totals Betting Market for National Basketball Association Games*, in *J. of Sp. Ec.*, vol. 1, n. 2, 2000, 177-186.

the final total posted by book makers was a better predictor of the actual total number of points scored in NBA games than the first total posted, suggesting that observed changes in the totals posted by book makers contain fundamental information about the games. Paul, Weinbach, and Wilson also examined total score betting in the NBA.[11] None of these papers examine betting volume on NBA games, or look for evidence of point spread shading by sports books in this market.

TABLE 1. SAMPLE MEANS

Variable	2003	2004	2005	2006	2007
Point Spread	3,56	3,48	3,36	3,44	3,38
Difference in Points	3,58	3,16	3,37	2,98	3,48
Home Team Favored	0,72	0,71	0,72	0,72	0,68
% Bet on Favorite	59,6	58,34	58,87	57,31	60,38
Winning %, bets on favorite	0,49	0,49	0,47	0,47	0,51
Observations	1135	1222	1230	1232	1240

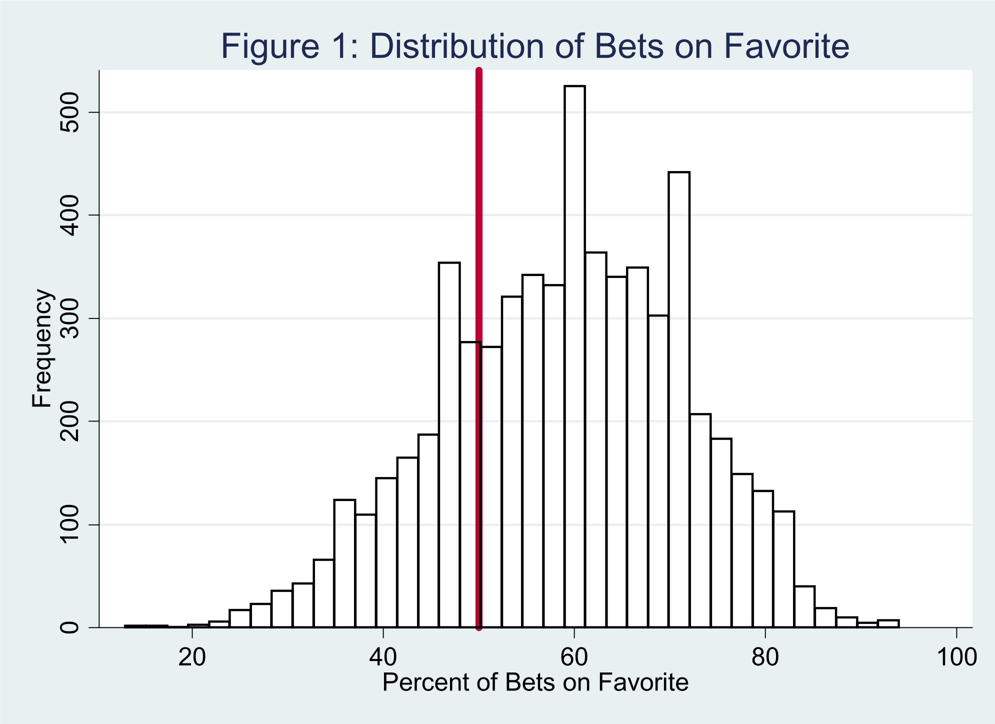
Table 1 shows sample averages for a number of key variables in this data set for each season. Note that the number of observations in each season varies because not every NBA game has a point spread and information about the volume of bets on each side in the data made available by Sports Insights. Home teams tend to be favored in NBA point spread betting, and home teams are, on average, favored by about 3.5 points per game. The point spreads set by sports books are quite close to the actual difference in points in the games. Given the previous evidence of efficiency of point spread betting markets in the NBA, the relatively small difference between point spreads and the difference in points scored should be expected.

The next two rows on Table 1 show several interesting features of the NBA point spread betting market. The home team is favored in the majority of games, reflecting the well-documented «home advantage» in sport. Note the lack of evidence of an equal volume of bets on either side in NBA games. NBA bettors wager heavily on favored teams. From the fourth row of Table 1, on average over these five seasons, between 58.3% and 60.3% of the bets were placed on the favored teams in NBA games. Bettors in this market appear to like to bet on the favored team. Recall that Levitt interpreted similar betting imbalances in point spread betting on NFL games as evidence of uninformed bettors.[12]

---

[11] R.J. PAUL, A.P.WEINBACH, M. WILSON, *Efficient markets, fair bets, and profitability in NBA totals 1995–96 to 2001–02,* in *The Quart. Rev. of Ec. and Fin.*, vol. 44, 2004, 624-632.

[12] S. LEVITT, *Why Are Gambling Markets Organised so Differently from Financial Markets,* cit., 2.



The averages on Table 1 do not convey the extent of the imbalance in betting on NBA games because the distribution of the variable is skewed to the right. Figure 1 shows the distribution of the fraction of bets on the favored team in the sample. The red line on Figure 1 is at the «balanced book» level of 50% of the bets on the favored team and 50% of the bets on the underdog. The overall sample mean is 58% and the median is 59%. Clearly, book makers in this market take positions on games, and allow bettors to wager heavily on favored teams.

The fifth row on Table 1 reveals the final interesting feature of this betting market: in every season except 2007/2008, bets on the favored teams lost more often than they won. Levitt reports that bets placed on favorites in NFL games also won less than 50% of the time, and cites this as evidence that book makers alter the point spread systematically to reduce the probability that a bet placed on the favored team wins.[13] The presence of uninformed bettors in the market makes it profitable for book makers to shade the point spread in a way to exploit the preferences of uninformed bettors by making it less likely that their preferred bet, a bet on the favored team to win, will pay off. The next section further investigates

[13] S. Levitt, *Why Are Gambling Markets Organised so Differently from Financial Markets*, cit., 2.

the probability that bets on favored NBA teams win.

3. Evidence of Shading in NBA Point Spread Betting

Recall that shading takes place when a sports book systematically changes the point spread on games to make it less likely that wagers placed by a majority of bettors will pay off. From Table 1, NBA bettors clearly prefer to bet on the stronger, favored team. Given this preference, shading takes place if the probability that a wager on the favored team is less likely to pay off, holding the point spread constant. One way to look for evidence of shading in NBA point spread betting is to investigate the factors that explain successful bets on favored teams using a regression model.

Let BFW_i be a dichotomous variable equal to one if a bet on the favored team in NBA regular season game i pays off and equal to zero if a bet on the favored team in game i loses. BFWi is a proxy for the variable π_1 in the model of sports book behavior above. To investigate the possibility that book makers shade point spreads to take advantage of uninformed bettors who prefer to bet on favored NBA teams, I estimate the unknown parameters of the model

$$BFW_i = a_0 + a_1 PS_i + a_2 PCTF_i + a_3 HF_i + e_i \tag{4}$$

using the familiar probit maximum likelihood estimator. In equation (4), PS_i is the point spread on game i, $PCTF_i$ is the percent of the bets placed on game i that are on the favored team, HF_i is an indicator variable that is equal to 1 when the home team in game i is favored, and ei is an unobservable random variable that captures all other factors that affect the probability that a bet on the favorite pays off in game i. a_0, a_1, a_2, and a_3 are unknown parameters to be estimated. BFW_i depends on a number of factors, including the point spread, the relative strengths of the teams involved, and random factors that take place during the course of play. The regression model reflects these factors.

Clearly, the point spread on the game must be held constant when examining the relationship between the fraction of bets placed on the favored team and the probability that a bet on the favored team pays off. However, including the point spread, PS_i, as an explanatory variable in this model raises the possibility that PS_i is correlated with the error term in equation (4), e_i. The model of sports book behavior developed above explicitly assumes that book makers set point spreads to maximize expected returns, and the error term captures factors like unobservable book maker decisions, so PS_i may be endogenous in equation (4). To account for this, I use an instrumental variables estimator to account for potential endogeneity. The first stage Ordinary Least Squares regression uses PS_i as the dependent variable and a vector of 58 indicator variables identifying the specific home and visiting teams playing in each game as explanatory variables. These instruments should be uncorrelated with ei and explain variation in point spreads because they capture the relative strengths, reputations, and other characteristics of the teams participating in each game. The fitted values from this first stage regression are used in equation (4) in place of the actual point spread variable, PS_i.

The parameter of interest in equation (4) is a_2, which captures the relationship between the fraction of bets on the favorite and the probability that a bet on the favorite pays off. If the estimate of this parameter is negative, then bets on favorites will be less likely to pay off in games with a larger imbalance in betting toward favorites. This would happen when book makers shading point spreads to take advantage of uninformed bettors who prefer to wager on the stronger team. The fraction of bets on the favored team, should be predetermined at the point when the game, and the outcome of a bet on the favorite, is determined. The home favorite indicator variable, HF_i, is included to control for home court advantage.

TABLE 2. INSTRUMENTAL VARIABLES PROBIT ESTIMATES
Dependent Variable: Bet on Favored Team Wins

Variable	Parameter Estimate	P-Value
Point Spread	0,026	0,035
Fractions of Bets on Favorite	-0,004	0,002
Home Team Favored	-0,159	0,003
2004 Season	-0,017	0,731
2005 Season	-0,049	0,347
2006 Season	-0,081	0,116
2007 Season	0,009	0,895
Observations / Log-Likelihood	6007	19078

Table 2 contains the marginal effects estimates for the regression model described by equation (4). Again, these parameter estimates were generated by an instrumental variables probit estimator that uses a vector of team indicator variables as instruments for the endogenous point spread variable. I also included indicator variables for individual seasons in the model to capture any systematic differences in betting across seasons. The results on Table 2 are robust to the exclusion of these variables. The marginal effect of changes on the point spread is positive and significant, suggesting that as the favored team becomes stronger than the opponent, bets on that favored team are more likely to win, other things equal.

Table 2 contains clear evidence that sports books shade point spreads to take advantage of uniformed bettors. First, the estimated marginal effect on the home favorite indicator is negative and significant. Bets placed on home favorites are less likely to pay off, holding the point spread constant. Recall from Table 1 that home teams are favored in a majority of games, and bettors like to bet on favorites. This parameter estimate suggests that sports books may take advantage of these factors in a way to make bets on favored home teams less likely to win. Second, the estimated marginal effect of the fraction of bets placed on the favorite is negative and significant; the more imbalanced the betting on a game toward the favored team, the lower the probability that a bet on that favored team pays off, no matter what the point spread on the game. The larger the imbalance in betting on the favored team, the larger the potential gain to the book maker if a bet on the favorite loses. This negative estimated effect is consistent with book maker shading of the point spread at any point spread.

The size of the estimated marginal effect is small. This is to be expected, because institutional factors in point spread betting markets limit the extent to which book makers can shade the point spread. Recall that wagers are evaluated at the point spread what was in place at the time that the bet was made. If a point spread was eight points early in the betting period, and moves to five points later in the betting period, an individual bettor could place bets on either team at either point spread. This leads to the possibility of arbitrage profit opportunities arising for bettors, who could place bets on different teams at different point spreads in a way to make a sure profit no matter what the outcome of the game. In the jargon of book making, the sports book could get «middled» on games when the point spread is changed too much. The potential for these arbitrage profit opportunities clearly limits the size of point spread shading by book makers.

4. Discussion and conclusions

Two competing models describing how book makers operate in markets for point spread betting on sporting events currently exist: the standard «balanced book» model, where informed bettors make wagers based on the point spread and their assessment of the relative strengths of the two teams and book makers set point spreads to balance the volume of wagers equally on either side of a game, and an alternative model including both informed bettors and uninformed bettors who make wagers based on factors other than the point spread. In this alternative model book makers exploit uninformed bettors by shading the point spread on games and operate an unbalanced book in order to increase expected returns. The evidence in this paper clearly supports the second model. Data on betting volume from more than 6,000 regular season NBA games over five seasons clearly shows that book makers regularly have unbalanced books on these games, and that in a majority of NBA games more bets are placed on the favored team than on the underdog. A balanced book on individual games appears to be the exception, not the rule in NBA point spread betting markets. If point spreads were set to balance betting on either side of games, the probability that a bet on the favored team pays off should be close to 50% over a large number of games. The probability that a bet placed on the favored team pays off in these data is less than 50%, providing unconditional evidence of point spread shading by book makers. In addition, estimates from an instrumental variables probit model indicate that the larger the imbalance in bets on the favored team, the lower the probability that a bet on the favored team pays off. This conditional evidence also suggests systematic shading of the point spread on games by book makers takes place in this market.

The empirical results here add to the growing body of evidence that point spread betting markets are more complicated than was previously thought. Book makers do not appear to act as passive market makers setting prices to balance bet volume and collecting a commission from bettors in these markets. Instead, book makers actively participate in point spread betting markets by taking positions on games and appear to systematically exploit uninformed bettors. In doing this, book makers assume more risk than they would by operating a balanced book.

The model presented in the paper motivates this behavior, showing that expected returns on games can be increased if biased bettors participate in these betting markets, in the sense that the subjective probability that a wager on the favored team pays off differs systematically from the objective probability. While this model is useful for motivating the empirical analysis in this paper, it falls short of a complete model of book maker behavior for several reasons. First, the choice variable in the model, the fraction of bets placed on the favored team, needs to be replaced with the point spread, because book makers clearly set point spreads in this market. Expanding the model to include the point spread as the choice variable requires explicit modeling of decisions made by both informed and uninformed bettors, as well as strategic interaction between informed bettors and book makers. The model of odds betting on parimutual horse racing developed by Hurley and McDonough suggests one possible approach for expanding the model.[14]

The results also suggest several important avenues for future research in this area. First, the ability of sports books to increase profits by shading point spreads depends critically on the relative number of informed and uninformed bettors in the market. No evidence currently exists about how many informed and uninformed bettors participate in point spread betting markets. Second, the empirical analysis presented here does not take into account the total volume of betting on each game; only the fraction of bets placed on each team is known in this data set. If uninformed bettors systematically bet on certain games, for example games involving teams with large fan followings or "superstar" players, then book makers could increase profits even more by shading the point spread on games with a high volume of uninformed bettors. At this point, little is known about how the total volume of bets varies across NBA games. Future research should look for additional

[14] W. Hurley, L. McDonough, *A Note on the Hayek Hypothesis and Favorite-Longshot Bias in Parimutuel Betting,* in *Am. Ec. Rev.*, vol. 85, 1995, 949-955.

evidence of point spread shading that varies systematically with the total volume of wagering on the game.

References

J. Conlisk, *The Utility of Gambling*, in *Journal of Risk and Uncertainty*, vol. 6, 225-75, 1993.

L. Coleman, *New Light on the Longshot Bias*, in *Applied Economics*, vol. 36, 315-326, 2004.

J.M. Gandar, R.A. Zuber, W.H. Dare, *The Search for Informed Traders in the Totals Betting Market for National Basketball Association Games*, in *Journal of Sports Economics*, vol. 1, n. 2, 177-186, 2000.

B.R. Humphreys, *Prices, Point Spreads and Profits: Evidence from the National Football League*, University of Alberta Department of Economics Working Paper n. 2010-05, 2010.

W. Hurley, L. McDonough, *A Note on the Hayek Hypothesis and Favorite-Longshot Bias in Parimutuel Betting*, in *American Economic Review*, vol. 85, 949-955, 1995.

S.D. Levitt, *Why Are Gambling Markets Organised so Differently from Financial Markets*, in *The Economic Journal*, vol. 114, 223-246, 2004.

R.J. Paul, A.P. Weinbach, *Bettor Misperceptions in the NBA: The Overbetting of Large Favorites and the «Hot Hand»*, in *Journal of Sports Economics*, vol. 6, n. 4, 390-400, 2005.

R.J. Paul, A.P.Weinbach, M. Wilson, *Efficient markets, fair bets, and profitability in NBA totals 1995–96 to 2001–02*, in *The Quarterly Review of Economics and Finance*, vol. 44, 624-632, 2004.

R. Sauer, *The Economics of Wagering Markets*, in *Journal of Economic Literature*, vol. 36, 2021-2064, 1998.

A. Tversky, D. Kahneman, *Judgment under Uncertainty: Heuristics and Biases*, in *Science*, vol. 185, 1124-1131, 1974.